Verification of AMVs in the T-PARC Period

Shunsuke Hoshino 1, Kazuki Shimoji 2, Ryo Oyama 2, Tetsuo Nakazawa 1

1 Meteorological Research Institute, 1-1 Nagamine, Tsukuba, Ibaraki, 305-0052, Japan
2 Meteorological Satellite Center, 3-235 Nakakiyoto, Kiyose, Tokyo, 204-0012, Japan

Abstract

1. INTRODUCTION

In the T-PARC 2008 period, the rapid scan observation with MTSAT2 are operated for the tropical cyclones over the Northwestern Pacific Ocean (NWP), mainly for Typhoon Sinlaku and Typhoon Jangmi. With these rapid scan data, the atmospheric wind vectors (AMVs) are calculated.

In this study, we validated the quality of these rapid scan AMVs. JMA plans to operate the rapid scan with MTSAT1-R and the calculation using those data, so the results of this study will help the further using of the rapid scan AMVs with MTSAT1-R.

2. DATA AND METHODOLOGY

In the T-PARC 2008 period, three sequential rapid scans are operated with MTSAT2, since 13UTC 10th Sep. to 05UTC 13th Sep., since 13UTC 17th Sep. to 11UTC 18th Sep. and since 13UTC 27th Sep. to 11UTC 28th Sep. In these periods, the four named tropical cyclones (TCs) and the two unnamed TCs passed over NWP (the best tracks of these TCs are shown in Figure 1). The AMVs are calculated at every hour using 15 minutes imagery intervals, at 01, 04, 07, 10, 13, 16, 19, 22 UTC with 4 minutes imagery intervals and at 02, 05, 18, 11, 17, 20, 23 UTC with 7 minutes imagery intervals. For calculation of AMVs, two algorithms are tested - one is the algorithm used in Meteorological Satellite Center (hereafter, MSC), and the another one is the algorithm that averaging matching-surface technique (Shimoji, 2010) is implemented to MSC (hereafter, S10). The important difference with the operational products is that the cumulonimbus cloud area are targeted (excluded for the operational calculation). The configurations of the calculations are summarized in Table 1. Hereafter, the configuration of the target box size, the search area size and the grid size are represented as TttSssDegxx (for example, T16S32Deg025 means that target box size is 16 pixels, the search area size is 32 pixels and the grid size is 0.25 degrees).

	Operational	**In this study**		
Target box size (pixels)	32	32	16	8
Search area size (pixels)	64	64	32	16
Grid size (degrees)	0.5	0.5	0.25	
Cb area	Not targeted	Targeted		
Imagery intervals (minutes)	15 / 30 / 60 (depends on time)	15 (at every hour) 4 / 7 (depends on time)		
Algorithm	MSC	MSC / S10		

Table 1: The summary of the configuration for the calculation of AMVs.

These AMVs are validated with the observed wind data of the sondes launched from the 15 JMA observatories, the two JMA research vessels and 28 other observatories in the east Asia and the islands in the Pacific Ocean (shown in Figure 1). The data but of JMA are obtained from Wyoming University. And we compared the AMVs with the dropsonde data launched from the Falcon aircrafts. The limitations of matching up are summarized in Table 2. In this paper, we will show only the AMVs with the infrared channel (IR, upper and middle layer only) and the water vapor channel (WV, cloudy area only) because the number of the comparison data for low layer with the IR, the visible and the short wave IR channel are too small. And the result of the T08S16Deg025 and the T16S32Deg025 AMVs will be shown in this paper (to focus on the probability of mesoscale AMVs with rapid scans).

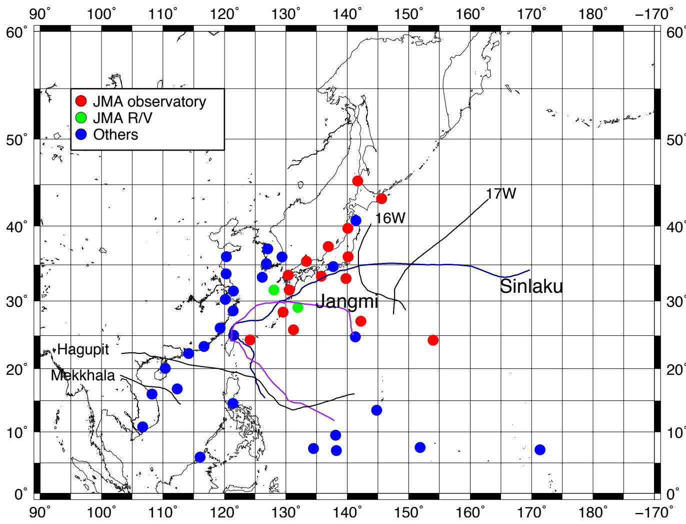

Figure 1: **The observatories used for the comparison. The red circles are the JMA observatories, the green ones are the JMA research vessels and the blue ones are the observatories of the other centers. The best tracks of the tropical cyclones that passed over NWP in the rapid scan periods are shown with lines (the four named TCs and the two unnamed TCs).**

	Collocation
Distance from observatories (deg lat)	0.5 (for grid=0.5) / 0.3 (for grid=0.25)
Height (hPa)	30 (for above 700hPa) 50 (for below 700hPa)
Time (hour)	0 (for 15 min. AMV) 1 (for 4 or 7 min. AMV)
QI	> 0

Table 2: **The limitation of matching up of AMVs and the observed wind data.**

3. COMPARISON BETWEEN AMVS AND OBSERVATIONS

The scatter plot for the comparison between the observed wind speed and the T16S32Deg025 15 min AMV wind speed are shown in Figure 2. The dashed line is the complete equivalent line and the two dotted lines represents that the errors are 10 m/s. The most of data is plotted between the two dotted lines, so it seems that the error for the most of the data is less than 10 m/s. The comparison between AMVs and the dropsonde data (the red symbols) are almost similar as the comparison with sonde data (the black symbols).

Figure 3 is the scatter plot of the QIs (without the forecast QI) and the relative vector differences (VDs) to the observed wind speed (the winds that the speed is below 5 m/s are not plotted). This figure shows that some of the data have the VD larger than twice of the wind speed and that VDs do not significantly correlated with QIs (some data have high QI but also have the large error).

The statistics of the comparison between AMVs and the sonde observations are shown in Table 3 (for IR AMVs) and Table 4 (for WV AMVs). These tables show that the VD errors are almost between 7 - 15 m/s. For T08S16Deg025 7 min IR AMVs, the error is significantly large for both algorithms. This is because of the case with the sonde wind speed is extremely high (about 150 m/s). The cloud will be drifted about 63 km is seven minutes by wind, and the size of the search area is about 64 km x 64km, so it is too difficult to chase the cloud pattern. If eliminated this case, BIAS, RMSE of the speed and RMSVD become -1.37, 7.81 and 10.39 for MSC and -1.79, 8.94 and 12.58 for S10, so that these are comparable with other configurations.

Totally, the IR AMVs have the smaller bias, on the other hand, the WV AMVs have the bigger bias. The magnitude of the bias are about 3 m/s at most for each configuration data sets. The RMSEs of the wind speed are about 8 m/s. The RMSVDs are 8 - 15 m/s.

The RMSVDs of MTSAT1-R operational AMVs with the QI larger or equal than 0.85 are 7.02 and 7.04 for IR (hight layer) and WV AMVs respectively (*1),so the accuracies of AMVs using MTSAT2 in the T-PARC period do not seem significantly different from MTSAT1-R operational ones.

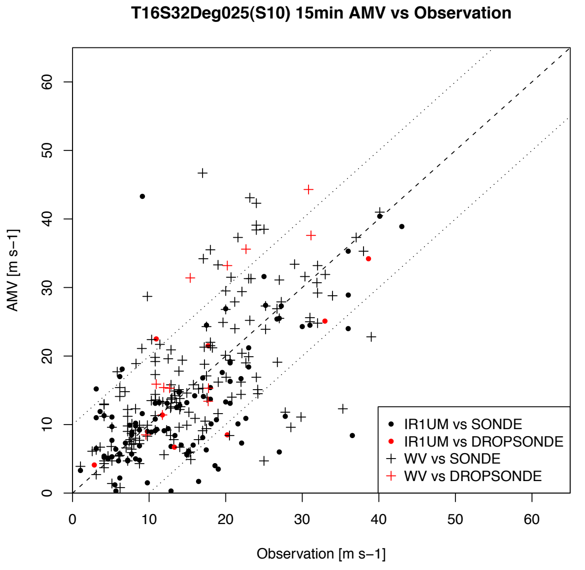

***Figure 2:* The scatter plot of the observed wind speed and T16S32De025 15min AMV. The black circle, the red circle, the black cross and the red cross represent the comparison between the IR AMV and the sonde data, the IR AMV and the dropsonde data, the WV AMV and the sonde data and the WV AMV and the dropsonde data, respectively. The dashed line is the equivalent line, and the dotted lines mean that the speed errors are 10 m/s.**

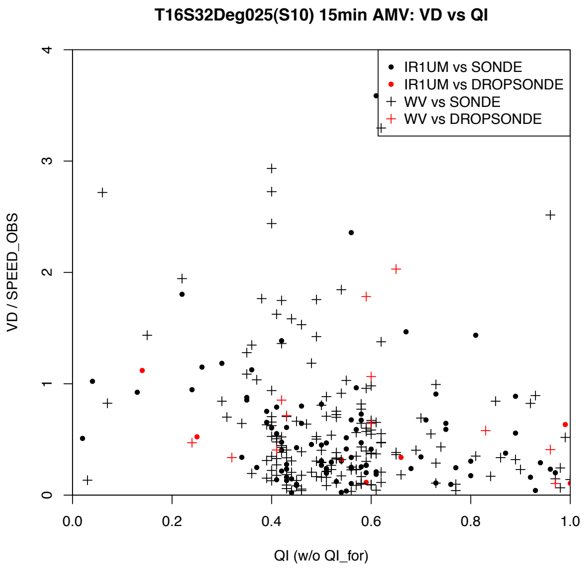

***Figure 3:* The scatter plot of the QI (without the forecast QI) and the relative vector difference to the observed wind speed. The meanings of the symbols are same as Figure 2.**

Configuration	Algorithm	Interval	N	BIAS	RMSE_Speed	RMSVD
T08S16Deg025	MSC	15	46	-1.02	5.56	8.06
		4	60	-1.39	6.87	9.41
		7	52 (51)	-4.06 (-1.37)	21.10 (7.81)	22.84 (10.39)
	S10	15	56	-2.05	8.74	10.40
		4	76	-1.17	7.90	9.94
		7	82 (81)	-3.48 (-1.79)	17.90 (8.94)	20.56 (12.58)
T16S32Deg025	MSC	15	92	-1.87	5.79	7.78
		4	83	-2.18	7.24	9.79
		7	78	-2.92	6.35	8.36
	S10	15	100	-2.28	7.90	9.91
		4	105	-1.87	7.96	11.10
		7	118	-1.52	8.45	11.61

***Table 3:* The statistics of IR AMV (upper and middle layer only) validation using the sonde data of the observatories. N is the number of matched up data, BIAS is the bias of the wind speed, RMSE_speed is the root mean square error of the wind speed and RMSVD is the root mean square of vector difference. The parenthetic value for T08S16Deg025 7 min AMV is the statistics for the data eliminating the especially strong wind case.**

Configuration	Algorithm	Interval	N	BIAS	RMSE_Speed	RMSVD
T08S16Deg025	MSC	15	127	1.32	5.72	8.70
		4	85	1.90	9.12	12.03
		7	86	1.31	6.41	9.34
	S10	15	137	0.36	7.48	12.03
		4	128	2.00	12.29	15.52
		7	143	1.12	14.03	17.35
T16S32Deg025	MSC	15	169	1.70	5.94	8.74
		4	123	1.88	8.83	12.44
		7	146	1.56	6.35	9.45
	S10	15	171	0.76	7.61	13.28
		4	181	1.91	9.67	14.44
		7	194	3.05	14.03	17.66

***Table 4:* The statistics of WV AMV (cloudy area only) validation using the sonde data of the observatories. The meaning of each columns are same as Table 3.**

4. HEIGHT ASSIGNMENT PROBLEM

To know the reason of the large error, we investigate the cases that the VD is extreme large. For example, we will show the case of the comparison between T16S32Deg025 WV 15 min. AMV and the observed wind data at Naze at 00UTC 12th Sep. 2008. The imagery of WV channel by MTSAT1-R (color) and T16S32Deg025 WV 15 min AMV (vectors) are shown in Figure 4. The cross symbol represents the location of Naze and the X symbol represents the location of the center of Sinlaku. The wind speed, the direction, the height of AMV is 18.9 m/s, 271.8 degrees and 386.5 hPa respectively. On the other hand, the observed wind speed is 8.29 m/s and wind direction is 3.46 degrees at this height. The both of the wind speed and the direction are quite different. Nevertheless, the QI of AMV is 0.80 (and 0.96 without the forecast QI), so this AMV seems the reliable according to QI. In Figure 4, Naze is located in the outflow region from Sinlaku, so the direction of AMV (westerly wind) seems reasonable. Figure 5 is the observed wind profile at Naze. The black line is the wind speed, the blue X is the wind direction and the red line is the AMV height. As mentioned above, the AMV is different from the wind at the AMV height, but corresponds with the wind about 250 hPa (the green dashed line). So it is possible that the AMV is correctly calculated but the height is miss-assigned. Figure 6 is the relative humidity profile at Naze (the black line is the observed data and the blue line is the forecast data). The observed humidity profile shows that it is dry at the AMV height and is characterized by the bimodal structure, and this structure also can be confirmed in the forecast profile. This 'multi-layer structure' makes the height assignment difficult and is one of the reason that the AMV accuracy become worse in this case. And this height assignment problem might be the reason of poor accuracy for the AMVs in the marginal region of the tropical cyclones, because there might be the upper cirrus and the lower cumulus, that is, the 'multi-layer structure', in those region.

The numbers of cases that relative VD is larger than 1.5 for each configurations and algorithms are shown in Table 5. The numbers of cases with the potentiality of large height miss-assignment, that the difference between the AMV height and the reasonable height subjectively assigned is larger than 50 hPa, are also shown. This table shows that the 30 - 50 % of larger errors are caused by height miss-assignment. The 'multi-layer structure' can not explain the all cases of miss-assignment, but is one of the major reasons.

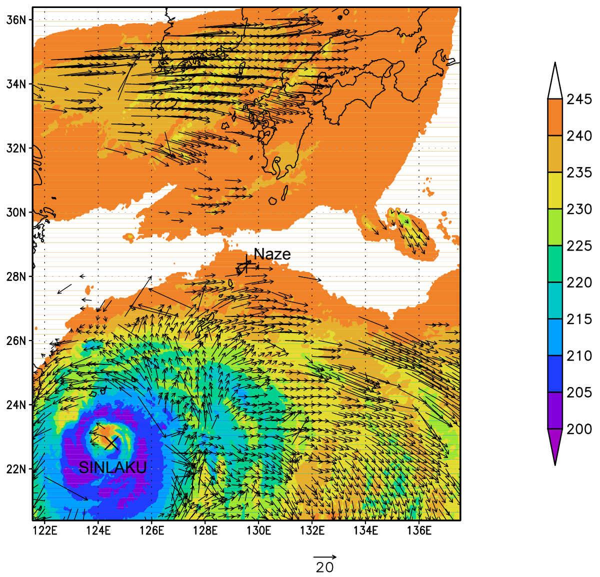

Figure 4: **The TBB of WV channel (color shade) and T16S32Deg025 WV 15 min. AMVs (vectors, plotted only QI>0.2 cases) at 00UTC 12th Sep. 2008. The cross symbol is the location of Naze and the X symbol is the center of Typhoon Sinlaku.**

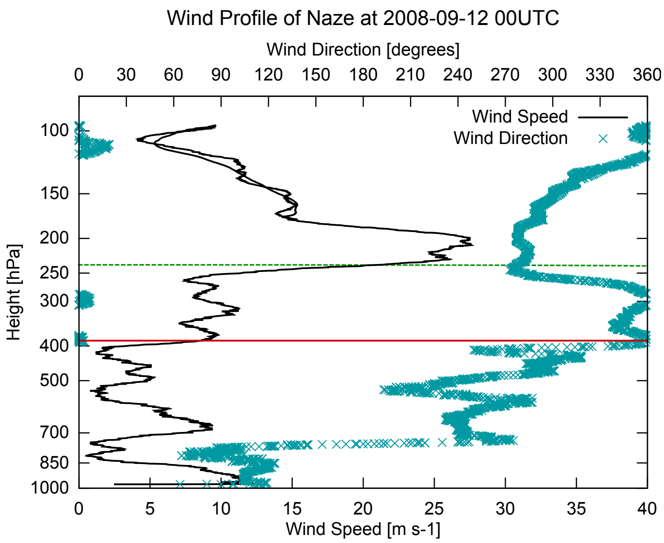

Figure 5: **The wind profile of Naze at 00UTC 12th September 2008. The black line is wind speed and the blue X is wind**

direction. The red line is the AMV height. The AMV corresponds with the wind at the green dashed line height (about 250 hPa).

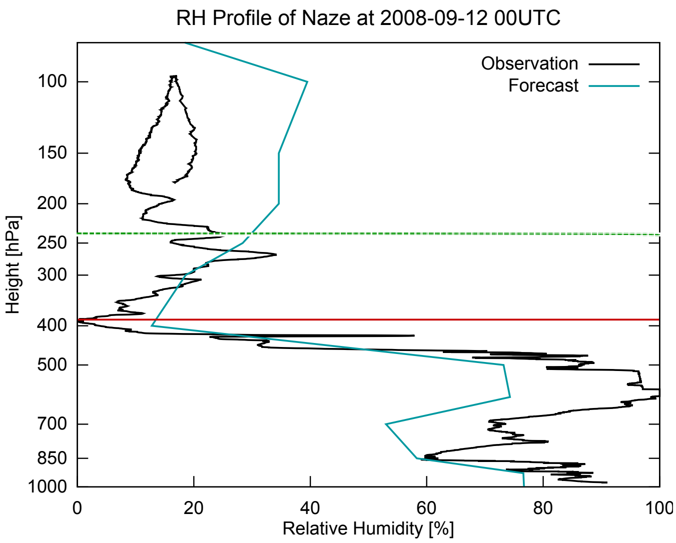

Figure 6: **The relative humidity profile of Naze at the same time with Figure . The black line is the observed data and the blue line is the forecasted profile. The red line is AMV height and the green dashed line is the height corresponding with AMV.**

Configuration	Channel	IR						WV					
	Interval	15		4		7		15		4		7	
	Algorithm	T	MA	T	MA	T	MA	T	MA	T	MA	T	MA
T08S16Deg025	MSC	1	0	4	3	4	3	7	3	8	2	5	2
	S10	3	1	5	2	6	4	7	2	14	3	13	8
T16S32Deg025	MSC	3	2	3	2	0	0	10	5	12	5	10	5
	S10	4	2	4	2	5	3	14	4	21	6	18	6

Table 5: **The total numer of cases that the relative VD is larger than 1.5 (T) and the number of cases of the difference between the AMV height and the reasonable height (assigned subjectively using observed wind profile) is larger than 50 hPa (MA).**

5. SUMMARY AND FUTURE ISSUES

In this study, the AMVs from the rapid scan using MTSAT2 in the T-PARC period are validated using the sonde data of the observatories and the research vessels and the dropsonde data launched from Falcon. For the wind speed, the biases are about 3 m/s at most, the RMSEs are about 8 m/s. For the VDs, the RMSVDs are about 8 - 15 m/s.

The 'multi-layer' humidity profile makes the assignment difficult. So in some cases, the height miss-assignments are the important factors of the large error even if the calculated AMV is reasonable and the QI is high. This problem is needed to be solved.

And the height assignment problem is the one aspect of the large errors. We have to know the other reasons of the large errors.

JMA will start the operational rapid scan with MTSAT1-R in 2010. The knowledge from this study will help the using the rapid scan data, and we have to develop the technique to use those data.

ENDNOTES

(*1) http://mscweb.kishou.go.jp/product/report/amv/2008/cgms_report_sep_2008.txt

REFERENCES

Shimoji, K. (2010) The development for MTSAT rapid scan high resolution AMVs at JMA/MSC. **The proceedings of the tenth international wind workshop**.